How To Fix Fractures Online 'Mini Series'

Session 1: How To Use Bone Plates and Screws

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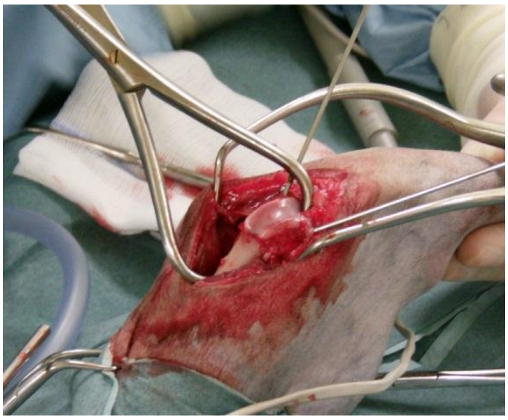


How To Fix Fractures- Session 1

Bone Plating

Learning Objectives

At the end of this section you should be able to:

- Discuss the relative advantages and disadvantages of bone plates to the other fracture repair options and apply this understanding to clinical cases
- Explain what is meant by the term “compression plating” and give an example of a fracture where this would be suitable
- Explain what is meant by the term “neutralisation plating” and give an example of a fracture where this would be suitable
- Explain what is meant by the term “bridge plating” and give an example of a fracture where this would be suitable
- Explain that *any* dynamic compression plate can be applied in either compression, neutral or bridge mode and that this is a function of how *you* insert the screws rather than being a function of the type of plate used.
- Explain what a lag screw is and give an example of a fracture where a lag screw would be suitable
- Be aware of locking plates and the basic biomechanical difference between locked plates and standard plates

These notes will deal with the principles and application of dynamic compression plates (DCP plates) which remain the most commonly used and relevant plates for small animal orthopaedics. Locking plates have largely replaced DCP plates in human orthopaedics however their use is still not widespread in veterinary orthopaedics. This will progressively change over the next 5-10 years. These notes will deal primarily with standard DCP plates.

Principles of Bone Plating

In 1958 a group of human orthopaedic surgeons in Switzerland formed the *Arbeitsgemeinschaft fur Ostosynthesefragen* (AO) to advance the techniques and instrumentation of internal fixation in orthopaedics. They revolutionised internal fixation of fractures developing techniques that allowed early return to function and consequently better fracture healing with less fracture disease.
This group is now worldwide and incorporates veterinary orthopaedics. It is known as the AO/ASIF (Association for the Study of Internal Fixation) group.

Their original goals of fracture repair were to:

- obtain anatomical reduction of fractures
- ensure stable internal fixation that satisfies the biomechanical requirements of the fracture
- preserve the fracture vascularity by atraumatic technique
- achieve early active pain-free return to function to limit the development of fracture disease

These goals have changed little in almost 50 years however with a better understanding of fracture healing (see *Decision Making in Fracture Repair in Orthopaedic Skills Course I*) should be slightly modified.

The goals of fracture repair should be:

- obtain stable anatomic fixation

  Stable fixation is essential. Anatomic reduction of articular fractures is essential. Anatomic reduction of diaphyseal fractures is desirable, however should not be achieved if the biological price outweighs the biomechanical gain. The concept of *biological* or *bridging osteosynthesis* is a relatively new concept that recognises this. Where anatomic reconstruction can not be achieved without considerable damage to the surrounding soft tissue attachments, bridging the fracture site with a plate or ESF or interlocking nail with minimal disturbance of the soft tissues is increasingly being used.

- asepsis in fracture repair
- maintenance of fracture vascularity / biology

Atraumatic technique is essential. Recognition of the importance of both the surrounding soft tissue attachments to the bone fragments and the growth factors present in the fracture clot has led to the development of bridging osteosynthesis and the "*open but do not touch approach".* The importance of thorough fracture assessment (see *Decision Making in Fracture Repair in Orthopaedic Skills Course I*) is emphasised. The surgeon must always ask the question when considering internal fixation "is the biomechanical gain worth the biological price?"

- early return to function

Achievement of all of these goals is not possible with every fracture repair however keeping these in mind and having a sound understanding of fracture assessment and the factors involved in fracture healing will increase success in fracture management.

Successful use of bone plating systems requires a sound understanding of the principles involved. The principles and decision-making necessary will be outlined.

1. What size plate should be used?

Plates are classified by the size of the screw they are used with. For example a 3.5mm plate is designed for use with a 3.5mm diameter cortical screw. The most commonly used sizes in small animal surgery are 2.7mm DCP (dynamic compression plate), 3.5mm DCP and 3.5mm broad DCP plates. (Broad DCP plates are a veterinary modification wherein the plate is actually the same size as the next larger plate size, a 4.5mm plate, but has the screw holes for 3.5mm screws. This will be discussed in more detail in the section on special plates.)

The plate size required for an individual surgery is <u>guided</u> by the AO/ASIF guide to plate sizes for specific bones. Considerable overlap exists however, which reflects the other factors that need to be considered in fracture assessment other than patient weight. For example the AO/ASIF guide lists either a 3.5mm DCP or a broad 3.5mm DCP or a 4.5mm DCP for a femur fracture in a 25kg dog.

Why such a large range in plate choices?

Exactly which of these plates should be used depends on a thorough **fracture assessment** of that individual case (see Orthopaedic Skills courses I and II). Significant points in the assessment that would make the stronger 3.5mm broad DCP a more suitable plate would include:

- A fracture that was not anatomically reconstructable and would therefore not achieve load-sharing on fracture fixation. This would place greater cyclic stress on a plate and increase the likelihood of premature plate failure.

- a fracture where healing was likely to be prolonged, for example a fracture with a poor biological assessment such as one with significant soft tissue damage or one in a geriatric animal or an animal with significant concurrent disease

- A fracture where clinical considerations such as animal compliance and / or owner compliance were expected to be poor.

Why not just use the largest size plate that will fit on the bone and be sure that it is strong enough regardless of the fracture assessment?

Repairing a fracture with too stiff a plate will lead to a condition called **stress protection** and consequent osteoporosis. This is the other extreme of load-sharing where the plate is so strong that it prevents the bone from carrying any of the load. This prevents the microstrain at the fracture line that is necessary for stimulating bone cells. Consequently bone resorption occurs as the bone has to carry little or no load and fracture healing is slower and ultimate bone strength is less.

The other theoretical consideration with respect to plate size is that as screw size approaches 40% of the bone diameter, the holding power of the screw decreases. This is not a significant clinical consideration in other than metacarpal and metatarsal fractures in smaller dogs and cats.

2. What length plate should be used?

Specific guidelines exist for the minimum length bone plate that should be applied. No specific guidelines exist for the maximum length however.

A <u>minimum</u> of 6 cortices either side of the fracture line should be engaged. This is the "*6 cortex minimum rule"*. This in most cases means at <u>least</u> 3 two-cortex screws (i.e. where the screw penetrates both the near or cis-cortex and the far or trans-cortex). In some cases fracture configuration may be such that insufficient bone stock exists proximally or distally to enable placement of 3 two-cortex screws (for example the distal radial fracture in the toy breed dog where often only two screws will fit distally). In these cases the 6 cortex rule may need to be broken. It is important to do this after full fracture assessment and only do this where the biomechanical assessment is reasonably good (in the example of the toy breed dog the dog's weight would mean the load on the plate would be relatively small). This should not be done in situations of poor biomechanical assessment such as large or giant breed dogs or multiple limb injuries as this will increase the likelihood of plate failure. (In examples such as these more versatile systems of fracture fixation such as a transarticular external skeletal fixators (ESFs) should be considered.)

What about the <u>maximum</u> length of plate to put on?

The general guideline is to use the longest plate that can be *comfortably* fitted to a particular bone without unnecessary soft tissue damage. For example in a mid-diaphyseal femoral fracture this would mean running the plate proximally to the end of the diaphysis and distally to the level of the branch of the femoral artery and vein.

How do you determine what the longest plate that will comfortably fit in that particular fracture is?

This is done through *fracture planning* and knowledge of local anatomy (review the surgical approach to the bone involved). Using a transparent acetate sheet or some tracing paper a tracing of the fracture is made in its reconstructed or reduced position. This may be done in two ways. The first is by tracing the radiograph of the intact contralateral bone and then tracing in the fracture lines on to that. The second and more commonly used option is to trace the proximal fracture fragment then reposition the acetate sheet and trace the distal fragment in a reduced position. This should be done for both radiographic views.
Once the “reduced” fracture has been traced an acetate sheet of the appropriately sized plate templates (these are available on request from Veterinary Instrumentation) is placed under the tracing and the optimal plate length determined.

This pre-planning eliminates the problem intraoperatively of not having the correct length or size of plate and also means that you can keep a smaller inventory of plates on the shelf, which reduces costs.

It is essential to remember when doing this that the radiographic image is *magnified* due to the distance between the bone and the x-ray film. A rule of thumb of 10% magnification is generally used.

Why not just use a 6 hole plate for all fractures?

While this would satisfy the *6 cortex rule*, in the majority of cases this would mean the plate applied would only occupy the mid-diaphyseal region. This can create a dangerously long lever arm proximal or distal to the plate, which concentrates stress at the plate end. This creation of a stress riser can lead to subsequent fracture of the bone at the end of the plate. This is more significant with long legged dog breeds. The longer the bone the more important it is to ensure that the plate at least spans the length of the diaphysis.

3. What equipment will be needed?

Having a full AO/ASIF set for the appropriate screw size to be used is ideal however this may be considered an unacceptable expense. The minimum equipment required for bone plating is:

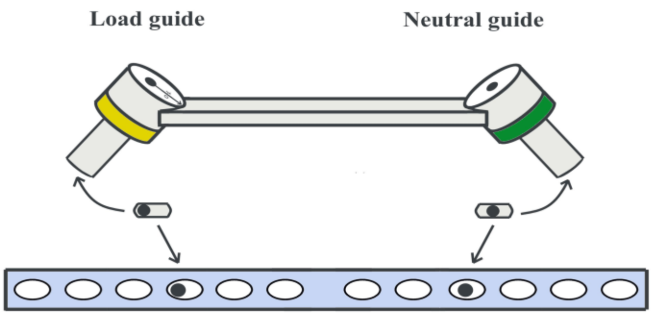
- 2 appropriately sized pointed reduction forceps (or some other type of bone holding forcep)
- 2 plate holding forceps to hold the plate firmly to the bone once the fracture is reduced
- An aluminium plate template of the appropriate size. These are cheap and reusable and greatly simplify contouring the plate to the bone. They should be considered *essential*.
- Some means of bending the plate to fit the bone. Various devices exist for this purpose including twisting irons, bending pliers and a bending press. Twisting irons are the minimum and advised requirement as they can be used to bend as well as twist plates. Bending pliers or the bending press simplify the process of bending however twisting irons will also be necessary.

- A power drill of some sort that can be used aseptically. Pneumatic drills are preferred because of their high speed and torque however rechargeable battery-powered drills with good torque are a reasonable alternative.

- A sharp drill bit of the appropriate size(s). There is an AO/ASIF table that lists the drill bit sizes for use with the various screw sizes either as a thread hole or a glide hole.

- the correct drill guides

- DCP drill guides have a guide at each end and are named by the plate size they are used with. Each has an oval-shaped foot that fits into the DCP plate hole. The neutral (green) drill guide (that actually produces 0.1mm axial compression), and a load (yellow) drill guide that produces 1mm axial compression. The neutral guide has the drill hole central in the plate hole while the load guide has the drill hole placed eccentrically. (This will be explained in further detail in the chapter on Dynamic Compression Plates).



- drill sleeves and insert sleeves of appropriate size if lag screws are to be placed

- The correct size depth gauge.
  This is necessary to measure the length of screw that needs to be placed. Due to the tapered point on the screw it is essential that the screw is far enough through to ensure that the threads on the screw shaft engage the far cortex and not that just the screw tip protrudes. Adding 1mm to the length measured on the depth gauge will ensure this. If in doubt it is safer to place a longer screw than place a screw that is too short.

- correct tap
  This is necessary to cut threads in the cortical bone as the most commonly used screws are non-self-tapping screws and need a thread cut into the cortical bone before they are placed.

  It is essential that the tap has the same thread profile as the screw being used. This is only a problem if different brand screws and taps are used, for example mixing Synthes (AO/ASIF) and Aescalup. (Note: Veterinary Instrumentation screws and taps have the same thread profile as the Synthes products.)

- tap sleeve
  It is important that taps are always used with a tap sleeve to prevent entrapment of surrounding soft tissue. It is good practise to get into the habit of *always* using a tap sleeve.

- correct screw driver
  AO/ASIF-type screws have a hexagonal recess and require a hexagonal head screw driver. The hexagonal head transmits the torque of the driver evenly to the screw unlike slot or cruciate recess screws and reduces the likelihood of the driver slipping out or stripping the recess. The same screwdriver will fit 2.7mm and 3.5mm screws.

4. Screw types

Screws are classified according to:

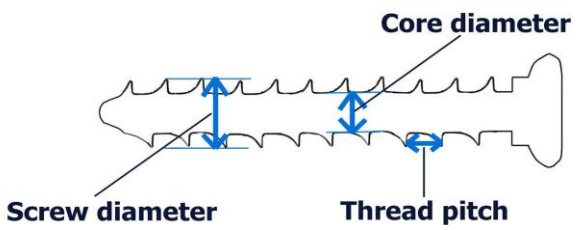
- their size
- the type of bone they are used in (cortical or cancellous)
- standard or locking screws
- the way in which they are inserted (self-tapping or non-self –tapping)
- their function (plate, lag or positional screws)

Screw size

Screw size is defined as the **thread** diameter of the screw. (For example a 3.5mm screw has a 3.5mm thread diameter.)

Other important dimensions of a screw are the **core** diameter and the thread **pitch**. This core diameter defines the screw profile. (For example the 3.5mm cortical screw has a core diameter of 2.4mm so the thread profile is raised 0.55mm above the core.)

The thread **pitch** is the measure of the *depth* of the thread (i.e distance between adjacent threads). Cortical screws have a narrow depth while cancellous screws have a relatively wider depth. (3.5mm cortical = 1.25mm pitch, 4.0mm cancellous = 1.75mm pitch)



It is essential to remember that every (non-self-tapping) screw has a corresponding drill bit and tap. Different brands of tap and screws should not be mixed (unless they are specifically intended for use together) as they may have a different thread pitch.

Screw diameter should not exceed 40% of the diameter of the bone.

The type of bone they are used in (cortical or cancellous)

Cortical screws are designed for use in hard cortical bone and are fully threaded along the shaft length. A cortical screw has a greater core/thread ratio than a cancellous screw. That is cortical screws have a relatively wide core, narrow thread and shallow thread pitch compared to cancellous screws which have a relatively narrow core (and therefore have decreased bending and torsional strength compared to cortical screws), wide thread and deep thread pitch.

Cancellous screws have a wide thread and deep thread pitch to increase screw holding power in the trabecular or cancellous bone of the metaphyses / epiphyses. The cancellous screw size most appropriate for use in small animals is the 4.0mm screw (1.9mm core diameter and 1.75mm thread pitch).

Cancellous screws may be either fully threaded like cortical screws or partially threaded. The fully threaded screws are designed for use as plate screws in the metaphyses / epiphyses. The partially threaded screws are designed for use as lag screws in the metaphyses / epiphyses.

As a general rule cancellous screws only require a thread to be cut in the near (cis-) cortex. The screw will cut its own thread in the soft cancellous bone.

Standard or locking screws

See the notes later in this section on locking screws.

The way in which they are inserted (self-tapping or non-self –tapping)

Non-self-tapping screws were the most commonly used screw type and require a thread to be cut into the bone. **Self-tapping screws** are designed in such a way that they may be screwed directly into bone and will cut their own thread. Self-tapping screws have increasingly become more commonly used than non-self-tapping.

The (theoretical) advantages of non-self-tapping screws are:

- They have considerably greater thread contact and depth (i.e greater “bite”) with the bone than self-tapping screws. (Whether this translates into greater resistance to pull-out seems to be unclear in research studies. It theoretically should as the thread core of the self tapping screw is smaller than the non-self tapping screw core but this has not been born out in studies to date))

- They generate less heat in placement than self-tapping screws because the tap used has a sharper cutting tip than the screw and has flutes designed to clear bone debris. (This advantage can be lost however if excessive heat is generated when drilling the pilot hole such as would occur with a blunt drill bit or where the flutes are not cleaned free of bone debris prior to each drill hole)

- They may be removed and reinserted without the risk of cutting a new thread. Self-tapping screws may cut a new thread if removed leading to loosening. (Provided that a self-tapping screw is re-inserted in exactly the same threads it does lose resistance to pull-out)

- They are suitable for use as lag screws (self-tapping screws should not be used as lags screws because of the risk of greater inaccuracy when they are placed obliquely)

The advantages of self-tapping screws are:

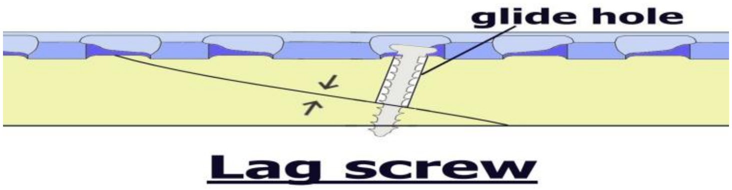
- they are quicker to place as they do not require tapping before placing
- they may be superior in very thin cortical bone and cancellous bone

I use self-tapping screws where possible.

Their function (plate, lag or positional screws)

Plate screws are designed to fasten the plate to the bone. In cortical bone cortical screws are used while in metaphyseal / epiphyseal regions cancellous screws should be used.

Lag screws are designed to produce interfragmentary compression. They are placed in such a way that the threads only engage the far cortex. Screw threads do not engage the near cortex either because the hole drilled in the near cortex is the same diameter as the thread diameter (a so called "glide hole") or the screw shank is only partially threaded such as in a partially threaded cancellous screw.



Positional screws are used to maintain the relative positions of smaller bone fragments when extensive anatomical reconstruction is attempted. They do not produce interfragmentary compression as screw threads engage both cortices. With the increasing trnd towards biological osteosynthesis rather than extensive anatomical reconstruction the use of positional screws is increasingly less common.

5. Applying the plate

- **Contouring the plate**

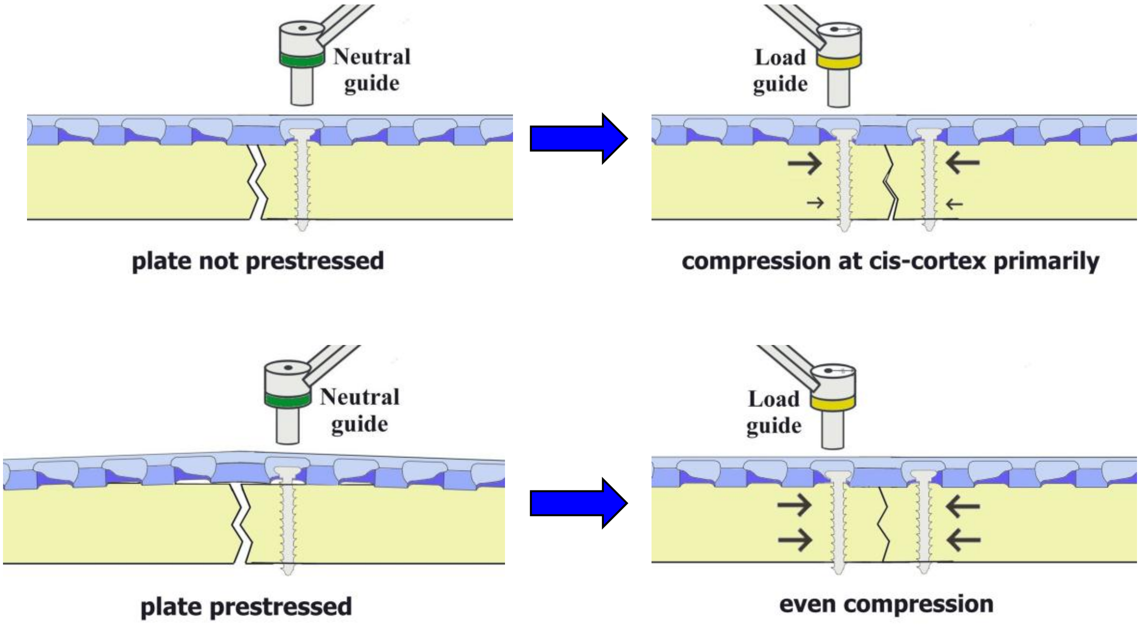
In fractures where anatomic reconstruction is intended the fracture should be reduced, and where possible depending on fracture configuration, then clamped in reduction with bone holding forceps. Bone holding forceps should be applied to permit placement of the aluminium plate template, and ultimately the plate, without having to reposition the forceps. Pointed reduction forceps or beetle jaw forceps are most useful in this regard.

The aluminium template of the appropriate size is then applied to the bone and contoured to fit. The pre-selected plate is then contoured exactly to the template. The contoured plate is then applied to the bone and any necessary adjustments made. Alternatively in fractures that are not anatomically reconstructable the plate can be contoured preoperatively to a radiograph of the intact contralateral limb. These radiographs must be taken to profile the surface of the bone to which the plate will be applied.

Contouring the plate may be done with various contouring instruments. The minimum requirement is a set of twisting irons which enable both twisting and bending of the plate. Ideally these would be used in combination with a set of bending pliers or a plate bending press. The pliers and the press greatly simplify bending and increase the accuracy of bending however these are significantly more expensive than the irons.

What about **overbending** or **prestressing** the plate?

This refers to the process of placing a slight bend in the plate adjacent to the fracture site to create a 1 – 2 mm gap between the plate and the bone. On insertion of the screws adjacent to the fracture gap the slight bend in the plate will cause compression of the opposite cortex. Tightening the screws in a plate that is not prestressed will actually create a slight gap in the opposite (transcortex) cortex. This is <u>only suitable</u> in simple two-piece fractures where perfect anatomic reduction has been achieved.



- **drilling the holes**

Generally the plate screws closest to the fracture line are placed first. Further screws are then placed alternating across the fracture line and working away from the fracture line towards the ends of the plate.

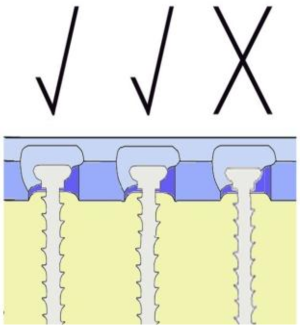
In short oblique fractures the fragment that forms an obtuse angle with the plate is fixed first to the plate. When the other fragment is compressed reduction will be maintained. If it is done in the reverse manner then static plate compression will cause loss of alignment. (This will be discussed in more details in the chapter on Application of Bone Plates)

For plate screws the drill bit size should be that recommended for the *thread hole* for that particular screw size. A drill guide should be always used. Either the neutral guide or the load guide should be used depending on whether static plate compression is intended.

It is essential that the drill bit used is sharp to limit the effect of thermal necrosis.

- **measuring the hole depth**

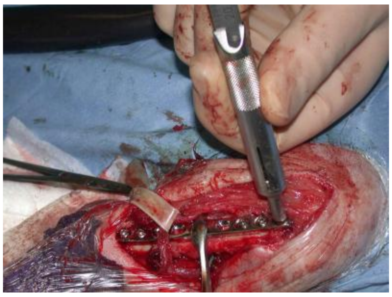
  The required screw length <u>must</u> be measured with the appropriate size depth gauge otherwise the measured depth will be incorrect. It is essential that the screw is long enough to so that the threads engage the far cortex. Generally 1mm is added to the measured depth to ensure this.



  Measurement should be done <u>before</u> the thread is tapped to prevent the angled tip of the depth gauge damaging the threads. It is important to remember that for non-self tapping screws the screw length <u>includes</u> the head (self-tapping screw length excludes the head and need specific depth gauges).

  Three depth gauges are needed to cover all screw sizes in small animal orthopaedics (however as most general practices use only 2.7mm and 3.5mm plates only one depth gauge is generally needed):

  - 1.5 and 2.0mm
  - 2.7, 3.5 and 4.0mm
  - 4.5mm



- **tapping the thread**

  This step is necessary for non-self-tapping screws with the appropriate size tap. It is essential to use the correct tap for the size and type (cancellous vs cortical, brand type). Tapping must be done carefully with a concentric movement involving the hand and wrist rather than the upper arm muscles, which creates an eccentric movement. Increased resistance is felt when the thread is being cut in each cortex. A second decrease in resistance signifies that the trans cortex has been completely tapped.

- **placing the screws**

  Each screw should be placed and tightened. After subsequent screws have been placed the previous screws should be checked for tightness and often may be further tightened.

  Note: Each hole should be drilled, measured, tapped and screwed sequentially. Drilling all the holes initially in a “batch” prior to placement of the screws should be avoided. While this will probably save time it may lead to malpositioning of the screws.

Locking Bone Plates

Increasingly we are using locking bone plates in veterinary surgery. Locking plates have largely replaced standard compression plates in human orthopaedics. Standard compression plates are still the most commonly used plates in general veterinary practice (which is why we mostly discuss standard compression plates in this section).

The majority of bone plates I would currently apply are locked plates, either the Synthes® locking TPLO plate (pictured below) or the LCP® (locking compression plate.)

Standard bone plates (dynamic compression plates) rely on the screw head compressing the plate firmly against the bone when the screws are fully tightened to provide stability. This works very well when:

- fractures heal fairly quickly
  - Fractures with poor biology (eg. which are likely to take >16 weeks to heal) can see loosening of conventional screws

- the plate and screws are not under great loads postoperatively
  - eg a comminuted fracture in a large or giant breed dog

- the bone is of good quality
  - for example it does *not* work well in osteoporotic bone in geriatric people. We rarely see osteoporosis in small animals so this is not such an issue for veterinary surgery.

In cases where bone quality is poor and/or fracture healing is likely to be prolonged and/or where biomechanical loads are going to be high and/or where the plate may need to be removed in the future then standard bone screws may loosen / the plate is then no longer tight against the bone / the fracture then becomes unstable / then non-union is likely to occur.
Locking bone plates have been developed to address these problems. Locking plates have almost completely replaced standard plates in human orthopaedics. In veterinary orthopaedics locking plates are not yet that common but are being increasingly used and are the way of the future.

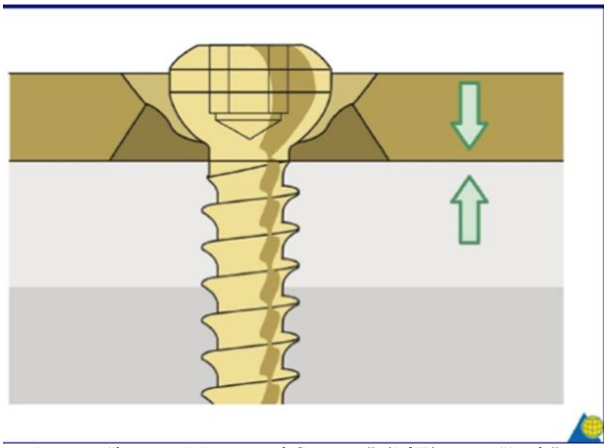
Stability of conventional bone plate constructs relies on maintenance of frictional contact between the plate and the bone. The plate exerts a compressive strain on the bone generated along the axis of the screws by the insertional torque applied to the screw.

This compressive strain has been shown to impair bone healing due to implant-induced periosteal avascularity which, after implant removal, can lead to a stress-riser effect and the potential for re-fracture. Plate removal following fracture union is uncommon in veterinary surgery unlike human orthopaedics where plate removal is more the norm.

Loss of plate compression through screw thread stripping is particularly a problem in osteoporotic human bone with conventional plating systems although again is not an issue for veterinary orthopaedics. Secondary osteoporosis from infection or disuse resorption is occasionally a problem and loss of compression in immature bone is recognised.

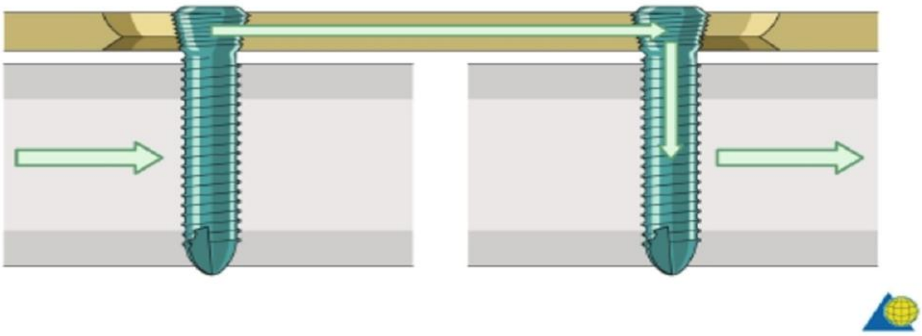
The images below are from the AOVet (www.aovet.org) web site. If you are particularly interested in veterinary orthopaedcis I would encourage you to have a look at this website and consider joining the AOVet group. They provide excellent practical educational courses around the world and undertake orthopaedic research internationally.

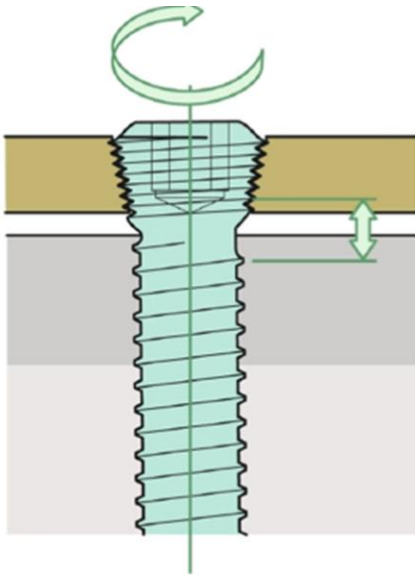
This image shows the function of a standard DCP plate where screw torque compresses the plate against the cortex. Maintenance of this friction is essential for stability.



Locked plates and screws may be considered as a “locked internal fixator” (LIF) and “bolt” and behave mechanically more like an external skeletal fixator (ESF) or interlocking nail (ILN) than a conventional bone plate. LIFs, ESFs and ILNs act as “splints” and are less rigid or more flexible methods of fracture fixation than traditional bone plates. Splinting is a more flexible method of fixation that should be used mainly in complex or comminuted fractures of the meta and diaphyseal segments of a long bone .

LIFs are a construct in which the physiological forces of weight bearing are transferred from the bone to the plate across the screw-plate threaded connection. LIFs form a single stable unit comprising the plate and the screws in which the stability of the fracture depends on the stiffness of the splint and the quality of the anchorage of the splint to the bone, rather than on the maintenance of frictional contact with the bone. Precise contouring of the LIF is not required because compression of the plate to the bone is not required to achieve stability.
The image below (www.AOVET.Org) shows the transferral of weight-bearing from the bone through the plate across the fracture gap. LIFs are designed to act as load-*bearing* fixation and so are ideal in comminuted and gap fractures.





Locking screws have a thread on the outside of the head that “locks” into a thread in the plate hole. This makes a more stable connection between the plate and the screw that can last longer, is more secure in poor quality bone and is less likely to loosen under large loads or prolonged healing.

The other big advantage of locked plates is that they do not have to be in direct contact with the bone to be stable. This means they do not impede the periosteal blood supply as the bone heals so the healed bone is stronger and less likely to fracture if the plate needs to be removed. Also because locked plates do not have to be in direct contact with the bone they can be applied through a MIPO (minimally invasive) technique.

Locking screw on the left (note the threads in the screw head that lock into the plate). Standard compression screw on the right

Locked screws are subject to cantilever bending forces and higher shear stress at the screw / bone and screw / plate junction than standard bone screws which are loaded along the screw axis.
To compensate for the altered loading of locked bone screws the screws in LIFs, the LCP systems have changed significantly compared to standard cortical screws.
The screw heads have a conically threaded profile which engages with the thread in the plate hole producing angle stable fixation in the plate.

The screw shafts have a **wider core diameter**, smaller thread pitch and smaller thread depth with increased core diameter to compensate for the increased bending moment and higher shear stress experienced in locked screws.

For LCP placement a minimum of two locking screws in each major fracture fragment has been shown in humans to adequately meet the increased bending and shear stresses although more are recommended in poor quality osteoporotic bone.

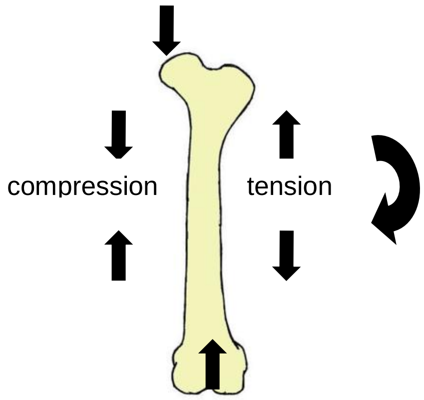
Since the introduction of Synthes LCP plates into veterinary orthopaedics there have been a number of other locking plate systems that have become available (SOP®, Fixin® amongst others.)

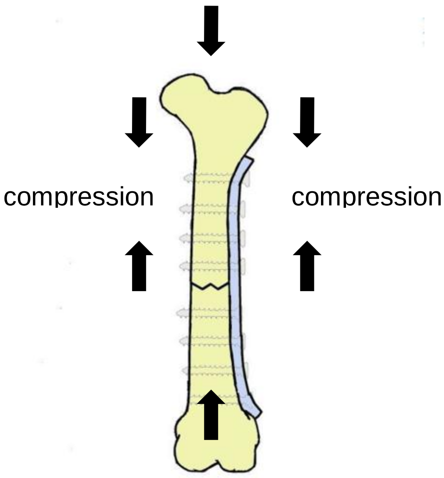
Application of standard (non-locking) Bone Plates

Plate design has advanced tremendously since the early plate types such as Sherman plates. The most versatile and widely used plate is the Dynamic Compression Plate (DCP), which was developed by the AO/ASIF group. More recently they have released the LC-DCP, which is a limited contact DCP plate.
This paper will deal with the application of and indications for use of DCP plates as these are the most appropriate plate for routine use in small animal orthopaedics.

DCP plates have specially designed screw holes that permit *static* compression of a fracture site should this be indicated. The term *dynamic* is somewhat of a misnomer as dynamic compression is not just a function of DCP plates. Dynamic compression is achievable with any plate type and is a function of bone shape, fracture configuration and the tension band principle rather than screw hole geometry.

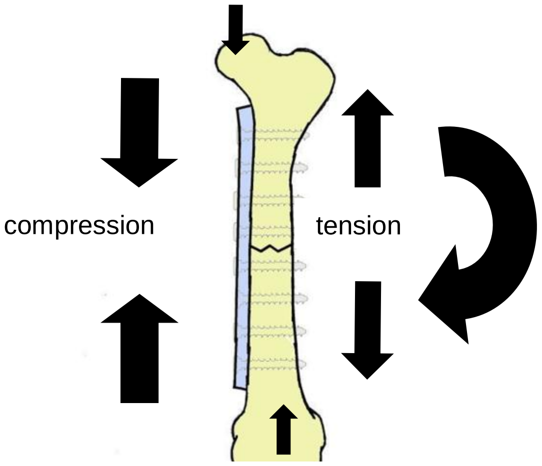
Most bones are loaded eccentrically because of their shape. Bone is a reasonably elastic material, which means that on weight-bearing the axial compressive force produced actually causes the bone to bend. On one side of the bone (the concave side) bending produces a compressive force while on the opposite side (the convex side) bending produces a tension or distractive force.

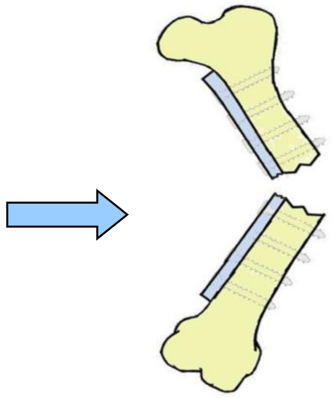




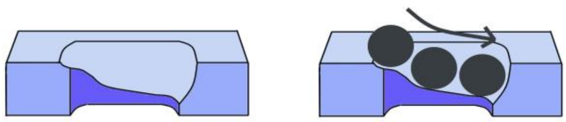
Providing that anatomic reconstruction is achieved, placing an inelastic device (such as a bone plate or a figure of eight orthopaedic wire) on the tension surface will actually convert the tension force into a compressive force. Clearly this is a desirable quality in stable fractures. The increased compression at the fracture site produced on weight-bearing increases the friction of the fracture surfaces and increases stability. Having the plate on the tension surface also serves to reduce the bending forces on it thereby increasing its fatigue life. This is the basis of the **tension band principle.** This principle is used in bone plating and in tension band wiring of avulsion fractures and osteotomies.

Conversely placing a plate on the compression surface actually increases bending force on the fracture and the plate and increases the likelihood of plate fatigue and ultimate fracture fixation failure:



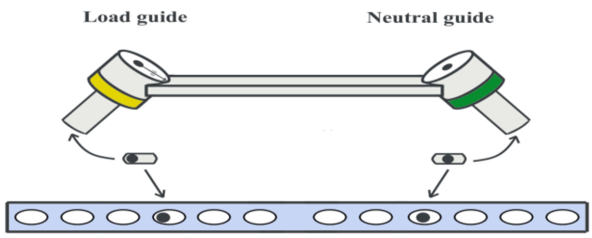


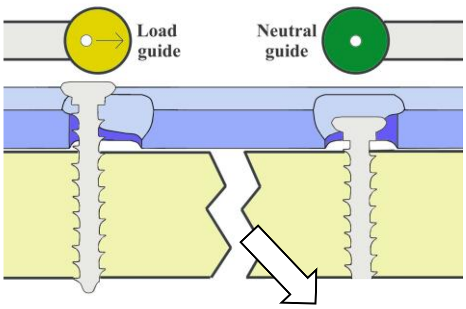
DCP plates should perhaps more logically have been termed *static* compression plates as static compression is what may be achieved through their unique screw hole design.
The holes utilise the “rolling ball”
or spherical gliding principle to allow static
axial compression by using a special “load”
drill guide.



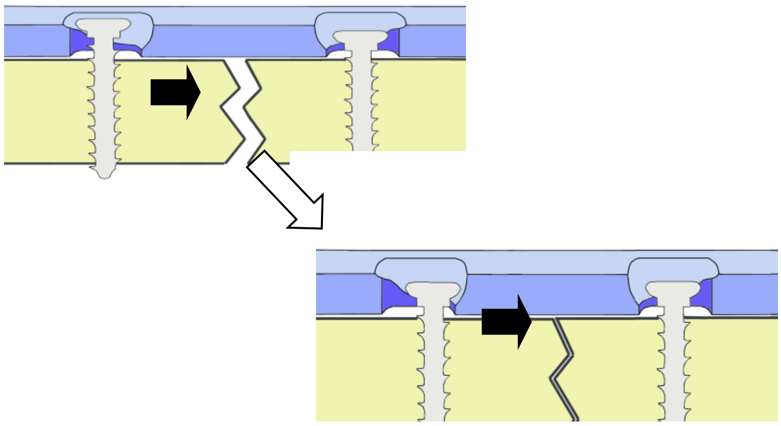
The plate holes are elliptical with an incline running towards the centre of the plate.

Special drill guides have been designed to utilise this “rolling ball” principle. Both the yellow load drill guide and the green neutral drill guide have an elliptical “foot” that exactly fits the screw hole. The neutral guide has its hole essentially centrally placed so that on insertion the screw head does not contact the incline in the screw hole. The load drill guide has an eccentrically placed hole that (providing it is used with the arrow pointing towards the fracture line) will place the screw hole at the end of the plate that is away from the fracture line.





Insertion of the screw causes axial compression on tightening as the screw head contacts the plate hole incline. The screw head or “ball” moves down the incline thereby causing compression of the bone. This method is generally termed *compression plating.* The neutral guide actually produces 0.1mm axial compression. The load guide will produce 0.8mm compression for 2.7mm DCP plates and 1.0mm compression for 3.5mm and 4.5mm plates.



The tremendous feature of the screw hole design that makes DCP plates so versatile is that by using a “neutral” drill guide the screws can be placed without achieving axial compression should this be necessary. When placed without axial compression this usage is termed either *neutralisation plating* or *bridge plating* depending on the fracture configuration.
It is essential to realise that static compression of a fracture with a DCP plate is a function of how the surgeon *chooses* to place the screws.

The screw hole geometry also allows some angulation of the screw within the hole without losing congruency between the screw head and the screw hole. In DCP plates the screws can be angled 27^{o} longitudinally and 7^{o} laterally. This is a very useful feature when lag screwing through a plate hole or when angling screws to avoid fracture lines or to avoid joints (e.g. the talocrural joint with distal tibial plates).

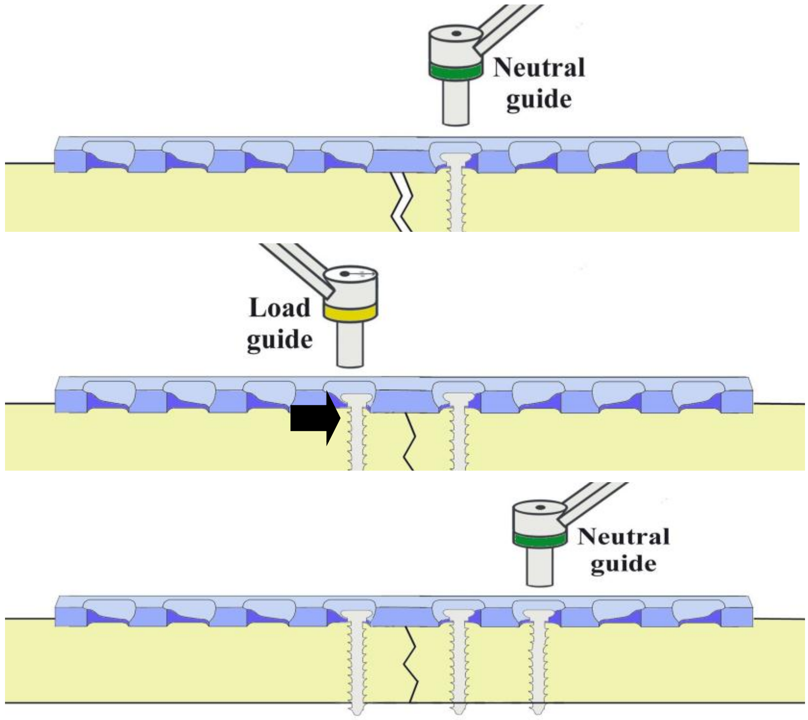
LC-DCP plates permit further angulation (up to 40° longitudinally) and allow compression in both directions. i.e both towards the centre of the plate and towards the end of the plate, which is useful in some segmental fractures.

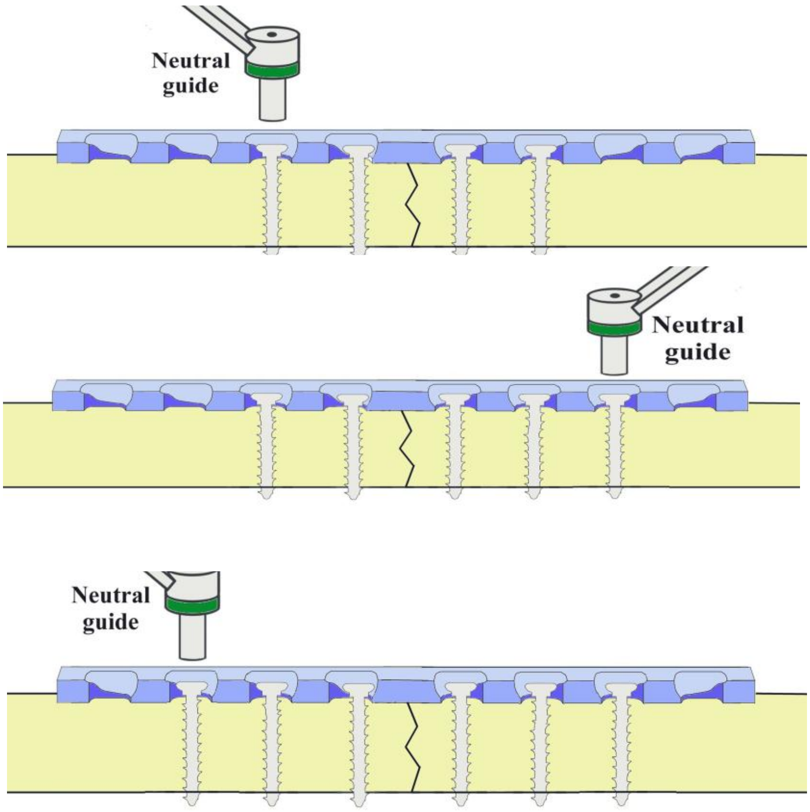
Compression plating

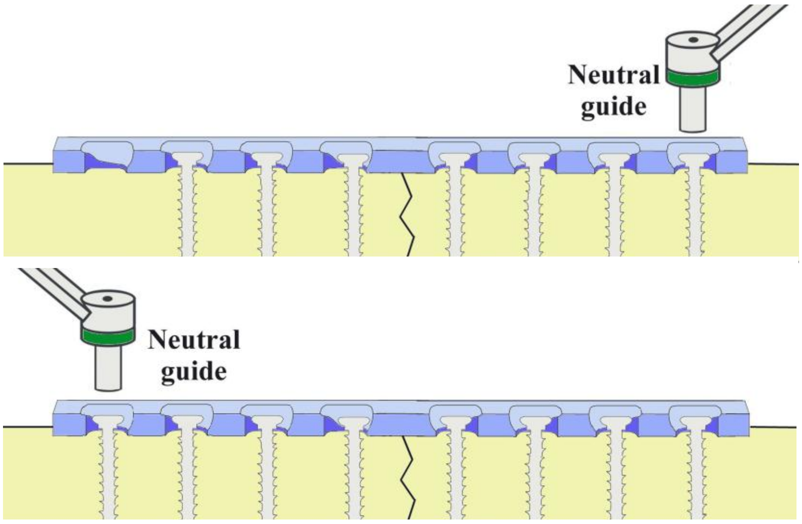
Choosing to use the static compression function of a DCP plate is indicated in:

- simple transverse fractures
- short oblique fractures.

The method of plate application in a transverse fracture is as follows (and assumes the fracture has been reduced and the plate has been appropriately contoured):

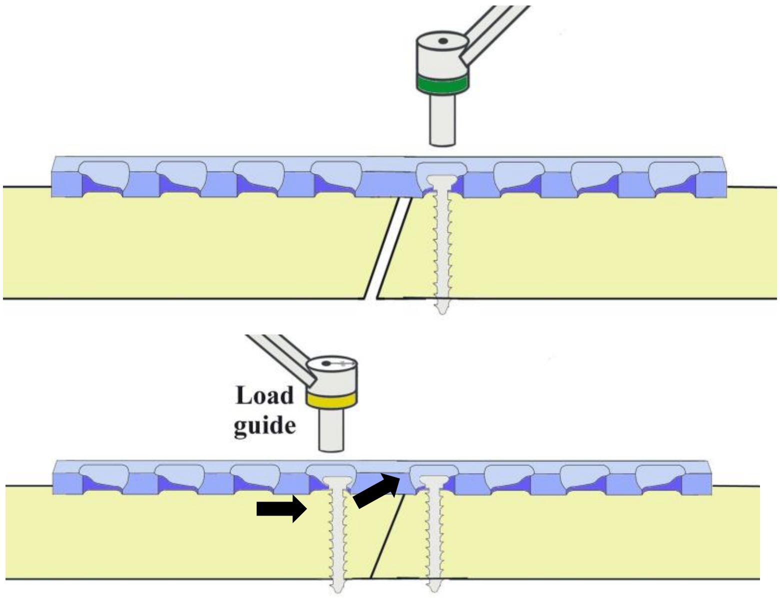




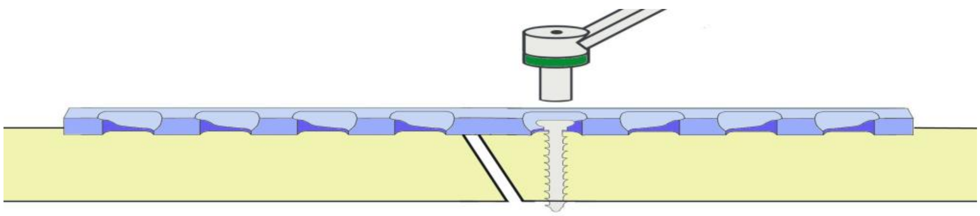


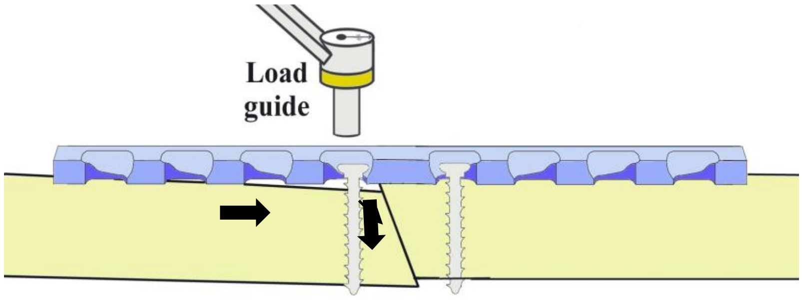
If additional compression is required the first screw can be placed as a compression screw and partly inserted. The second screw is then also placed as a compression screw and then both screws are tightened.

With oblique fractures it is very important to place the first screw in the bone fragment that will form an obtuse angle with the plate. This will mean that on compression of the fracture the acute fracture fragment will be forced into the space between the bone and the plate, thereby maintaining alignment.



The alternative method (shown below) is incorrect. If the first screw is placed into the fragment that forms the acute angle with the plate, when compression is produced on placement of the second screw in a load position loss of alignment at the fracture site will occur.





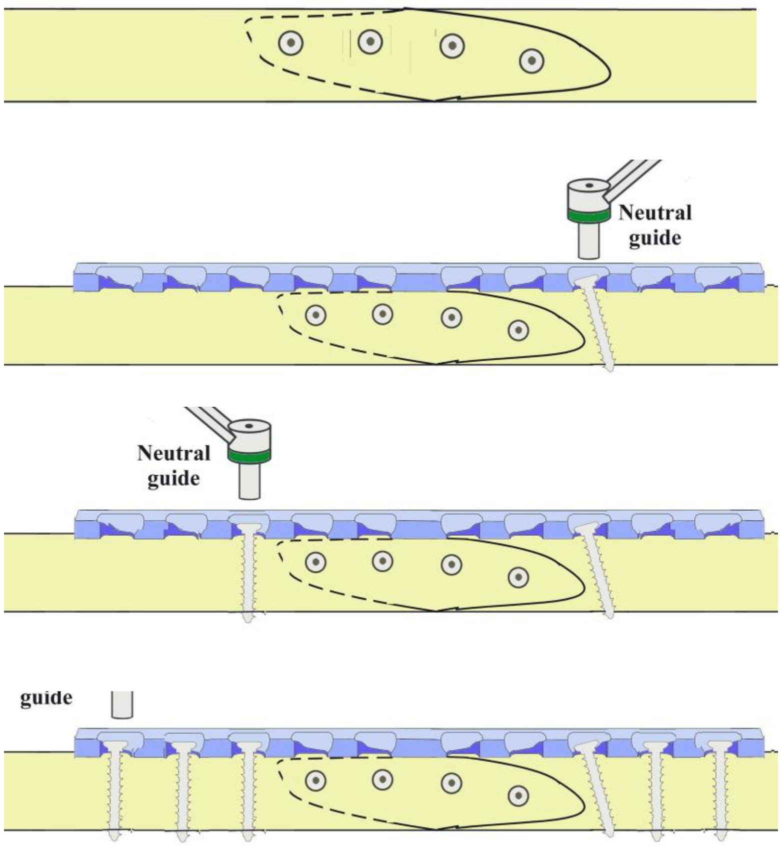
Neutralisation plating

The indications for the use of plates as neutralisation plates are:

- long oblique fractures
- comminuted fractures that are anatomically reconstructable

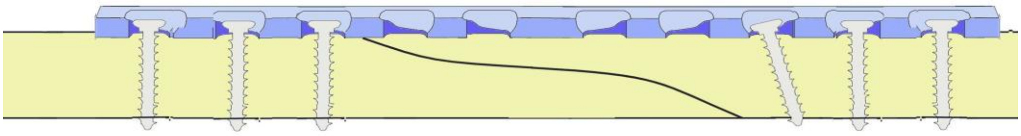
In these fractures anatomic reconstruction and interfragmentary compression is generally achieved with lag screws. Lag screw fixation of diaphyseal fractures alone is not sufficiently stable to resist the physiologic fracture forces produced on weight-bearing. The lag screw repair is reinforced or “protected” with a bone plate.
It is important to note that while anatomic reconstruction and neutralisation plating achieves some degree of load sharing it is not as great as that achieved with fractures that may be compression plated.

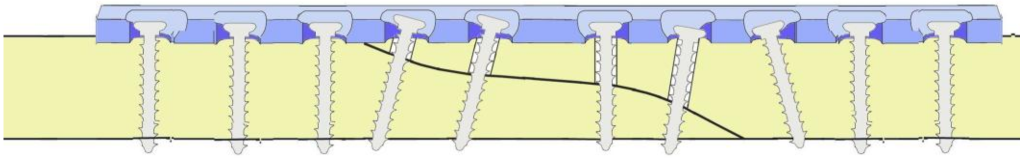
Initial lag screw repair of long oblique fracture



It is essential that a neutralisation plate be applied without static axial compression as this would disrupt the interfragmentary compression of the lag screws. The plate is applied to the compression surface of the bone with all screws placed with the neutral load guide.
It is also very important that the plate is contoured accurately to the bone to prevent disruption of the lag screw repair as the plate screws are tightened. The use of aluminium plate templates greatly simplifies accurate plate contouring.

Depending on the fracture configuration lag screw reconstruction may also be achieved through the plate holes. The other plate screws are still inserted with the neutral drill guide.



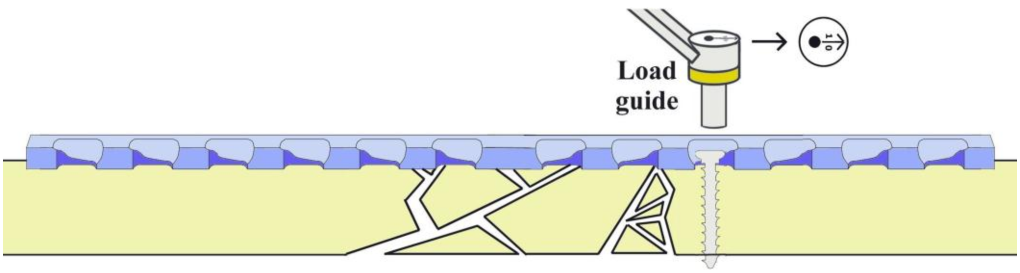


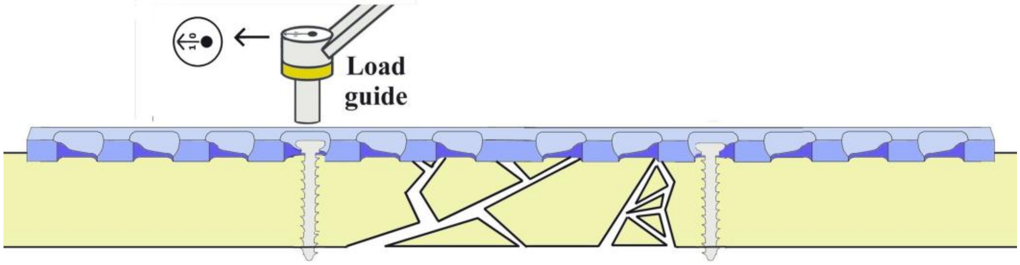
Bridge plating

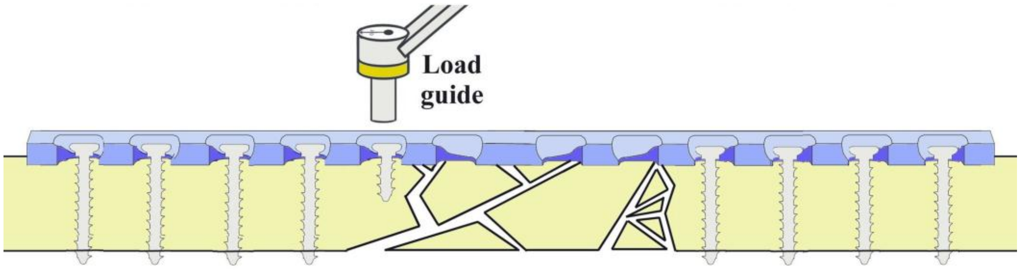
The indications for the use of plates as bridge plates are:

- highly comminuted fractures that are not anatomically reconstructable and where a bone deficit consequently exists

In these situations the bone plate bridges or spans the fracture site and transmits the *entire* load of weight-bearing. Load sharing is not achievable and consequently the plate is much more vulnerable to fatigue failure.
Axial compression of these fractures is not wanted so the screws are placed with the load drill guide with the arrow pointing **away** from the fracture. (The neutral drill guide is not used as it actually produces a small amount, 0.1mm, of axial compression.)



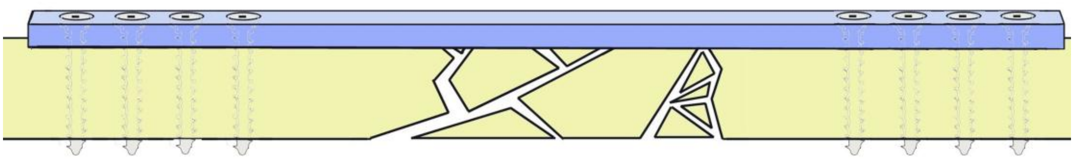




Options to decrease the likelihood of plate failure when repairing a highly comminuted fracture include:

- Make every effort to maximise fracture healing. An “open but do not touch” approach to maintain fracture biology and the use of cancellous bone grafts are particularly important.

- Use a plate other than a DCP plate if possible such as a **locking compression plate (LCP)** or leg-lengthening plate. These plates are very useful in highly comminuted fractures as they only have screw holes at either end of the plate. The central section is much stronger as it is not weakened by having empty screw holes over the fracture site. The plate is contoured prior to surgery based on a radiograph of the intact contralateral bone (remember that the radiographic size of the bone is magnified – a rule of thumb of 10% magnification is used).



Leg-lengthening plate

- If a DCP plate is to be used :
    - Use a larger size plate. For example use a 3.5mm broad plate (same dimensions as a 4.5mm plate) instead of a 3.5 mm plate.

    - Consider reinforcing the plate with an intramedullary pin as adjunctive fixation – **the plate-rod technique** (see the next chapter). The adjunctive use of an IM pin approximately 30-40% medullary diameter greatly increases the resistance of the plate to fatigue failure through bending.

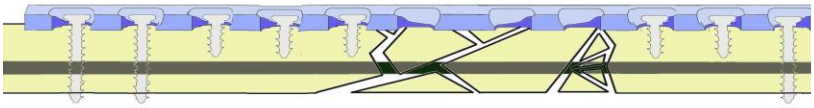


Plate-rod method

- Consider an alternate method of bridging or biological osteosynthesis such as external skeletal fixators or interlocking nails.